

# An optimization model for nutritionally adequate, affordable and culturally acceptable diets under planetary boundaries in Chile

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## Background and Aim

Half of current food production relies on Planetary Boundaries (PB) transgressions. No study this far has assessed sustainable diets in four sustainability dimensions simultaneously. Despite the growing global evidence, little research has been conducted for the LAC Region.

**The objective of this study** was to develop a mathematical model that incorporates four dimensions to propose a feasible sustainable diet at the national and sub-national levels, which could be adapted to any population.

Gerten et al., 2020; Afshin et al., 2019; FAO et al., 2024; Tulloch et al., 2023.

## Methods

### Data collection

- Published & public data.
- FAO & WHO nutritional recommendations.

### Food consumption data

- National & international country data.
- Chilean national food consumption survey vs FAO data.

### Food grouping & portion sizes

- SUA by FAO, 19 food groups.

### Nutritional composition data

- INFOODS for LAC.
- + sugar, vitD, vitB12, fiber (national & USDA).

### Environmental data

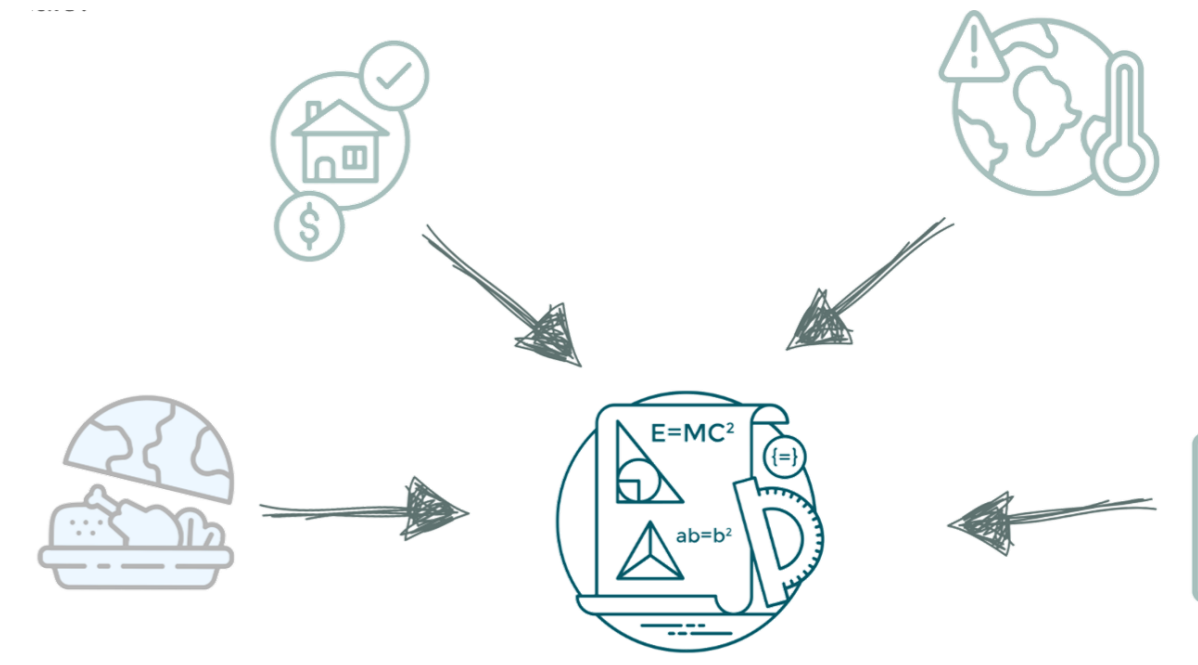
- WWF database (2020) + Springmann et al (2018) at country level.
- Planetary boundaries from Willet et al (2019).

### Cost & affordability data

- EPF + CASEN.
- 52% affordability threshold.

### Optimization

- 4 novel non-linear mathematical optimization models were developed: REF, GHG, COST, HBQ, MOGHG.
- GAMS studio was used.
- Dimensions used: nutritional, environmental, economic, cultural.
- The cultural dimension weighted twice.

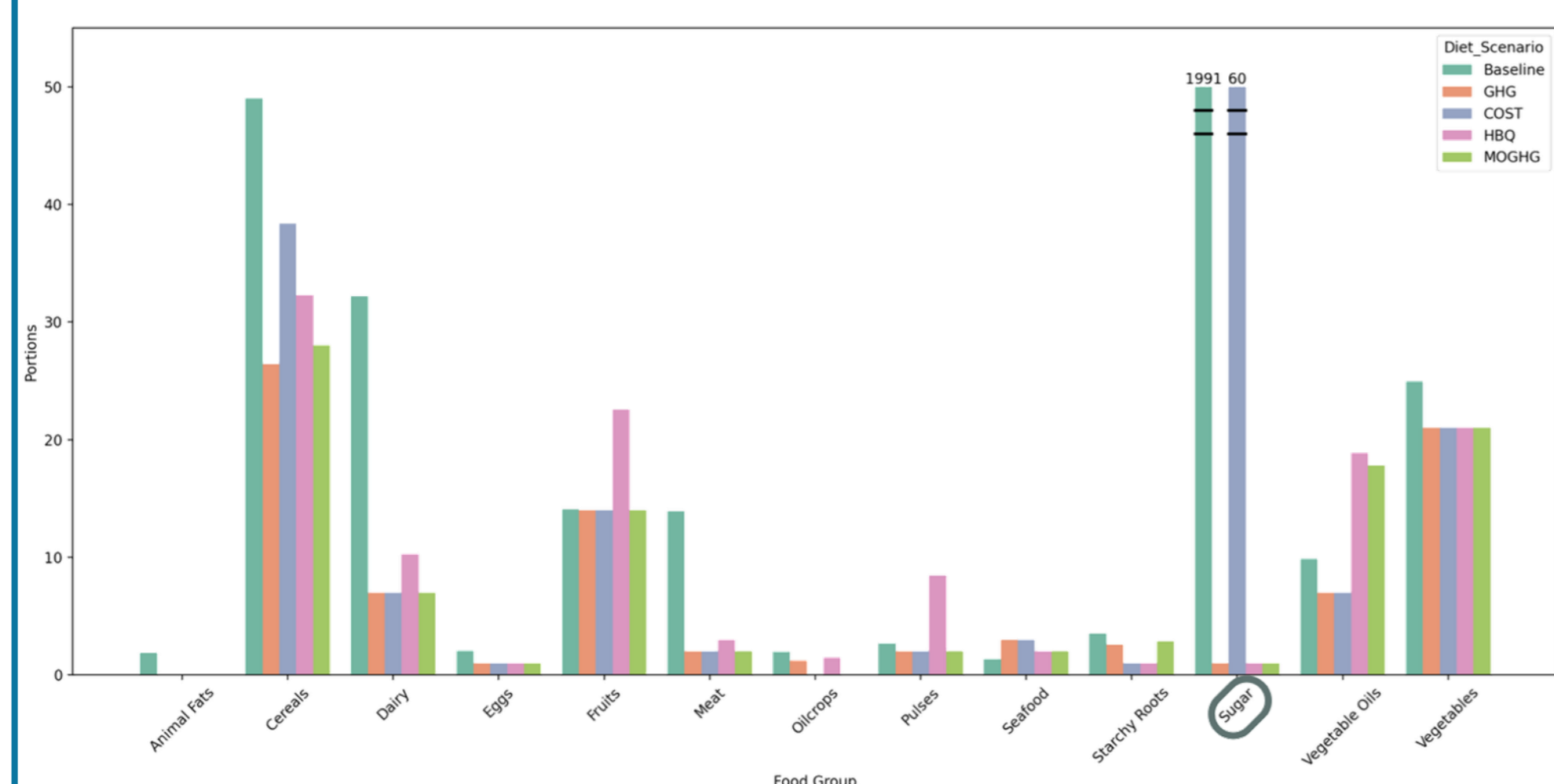


## Results

- Compared to the baseline diet (REF), the optimized diets reduced environmental impacts by 39-90% across indicators (3), lowered costs by 61-80% (data not shown), and met all nutritional requirements (2) while maximizing cultural acceptability (1).
- The optimized diets reduced the consumption of sugar, dairy, and meat while increasing the intake of fruits, pulses, and seafood (1).
- The environmental impacts were reduced below the planetary boundaries for most of the indicators (3).
- Unlike the baseline diet, the optimized diets were affordable across all income quintiles (4).
- Key differences were observed between population subgroups, with men, adults, urban residents, and higher-income quintiles, which generally have higher environmental impacts and costs in their baseline diets (data not shown).

### 1. Cultural dimension

Differences in weekly foodportions per optimization model

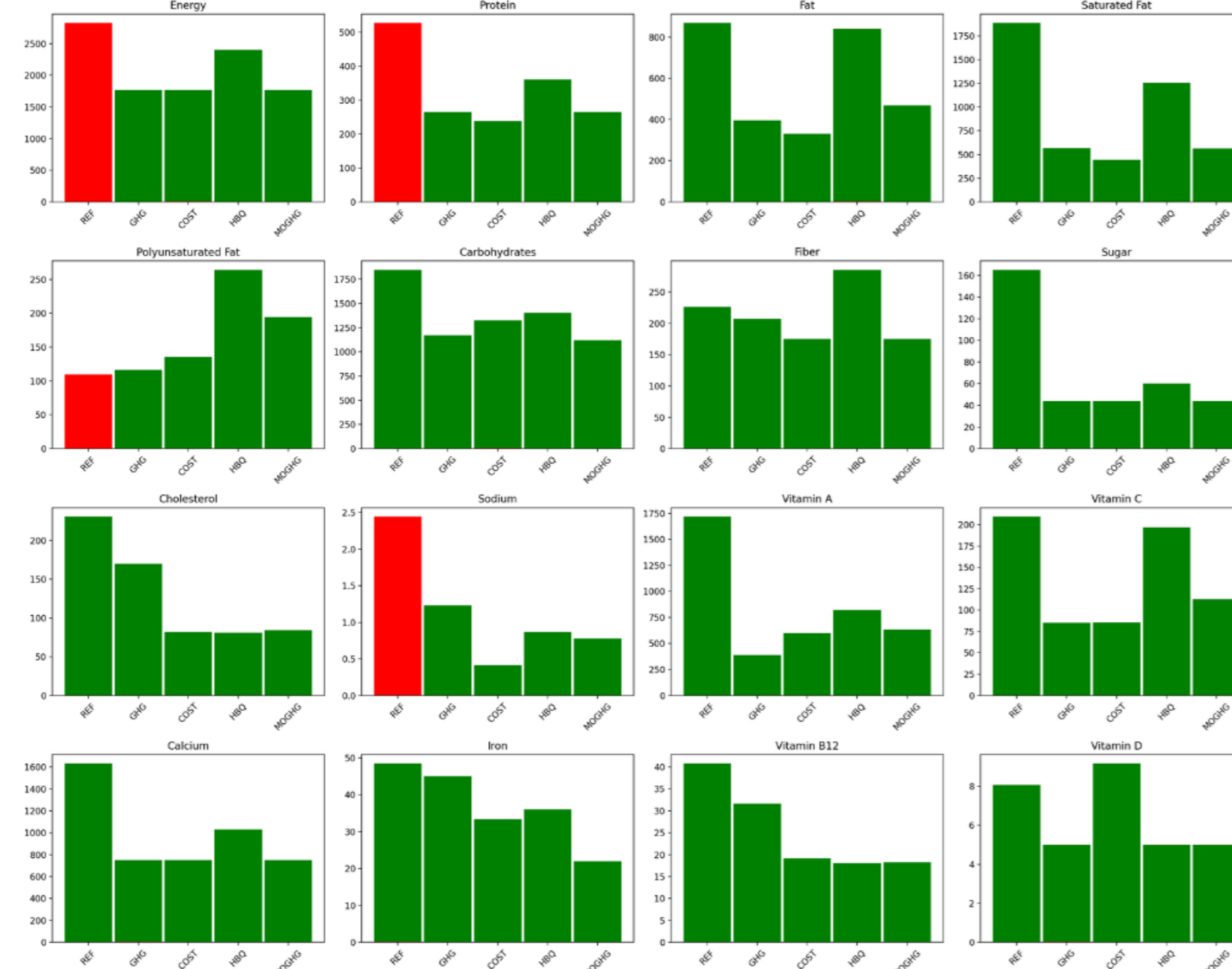


Note: GHG: greenhouse gasses model; COST: affordability model; HBQ: cultural model; MOGHG: multiobjective optimization model.

All results are for the adult population (>18y/o).

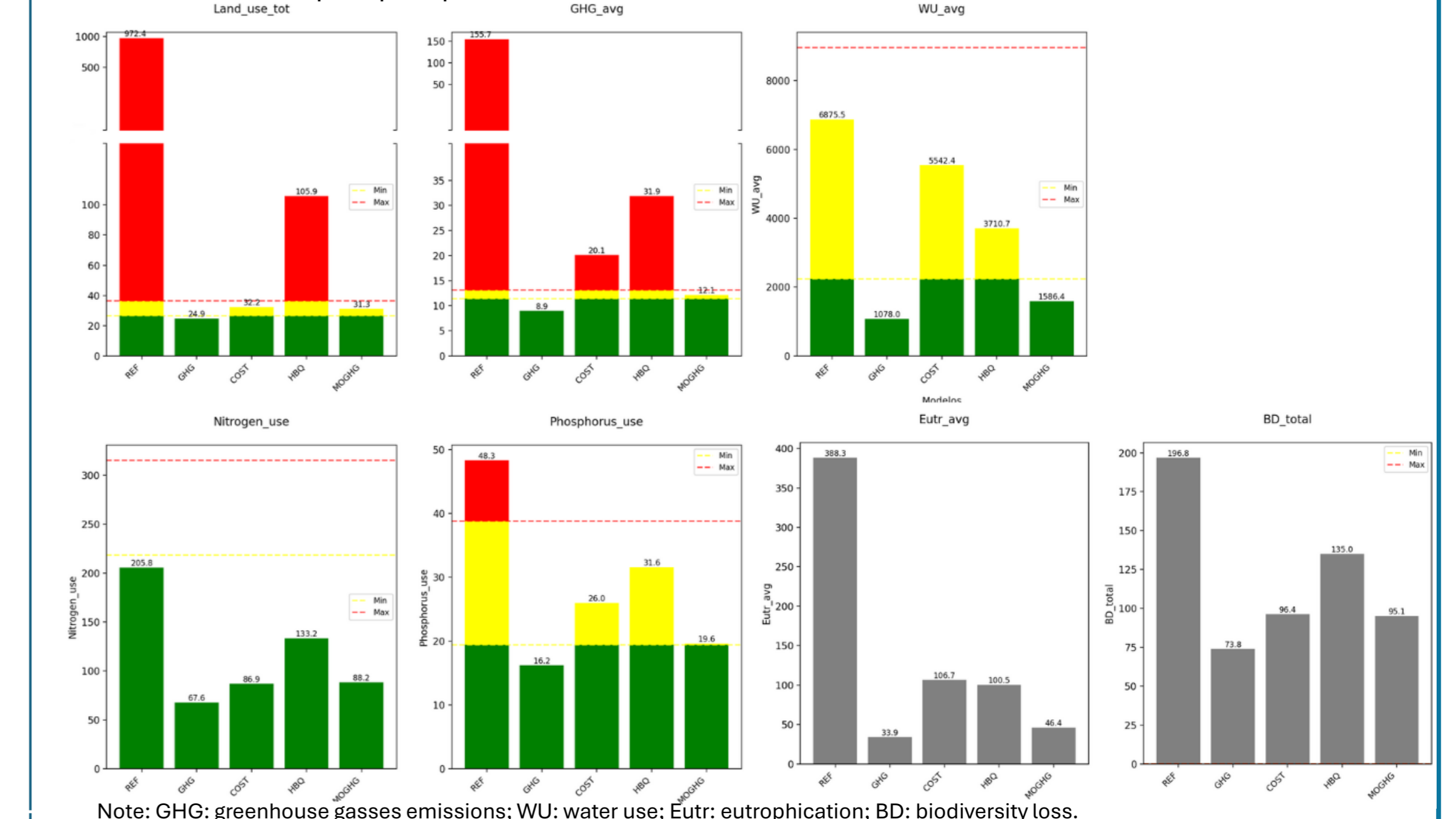
### 2. Nutritional dimension

Nutritional content of different optimization models compared to baseline diet



### 3. Environmental dimension

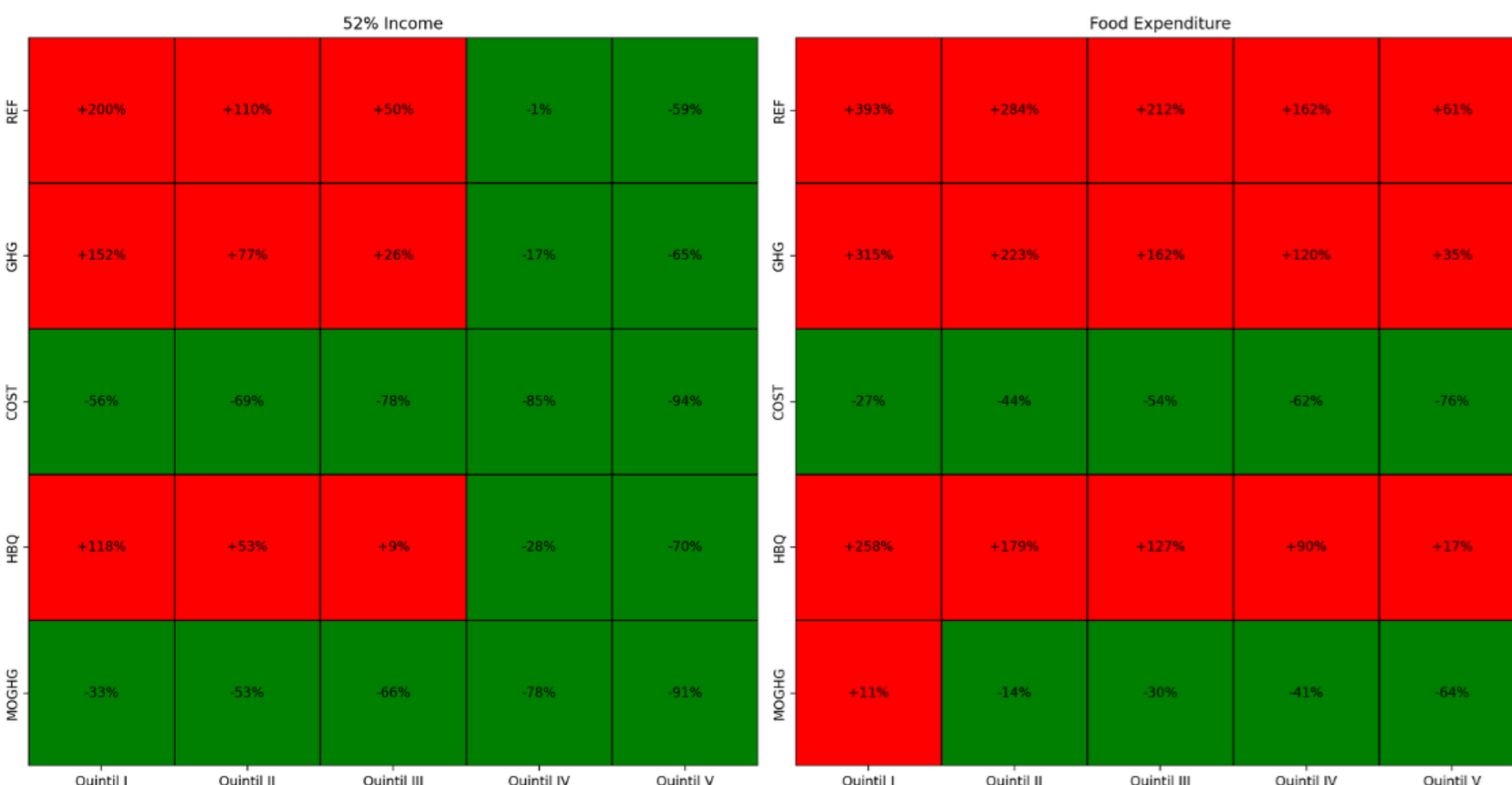
Environmental impact per optimization model



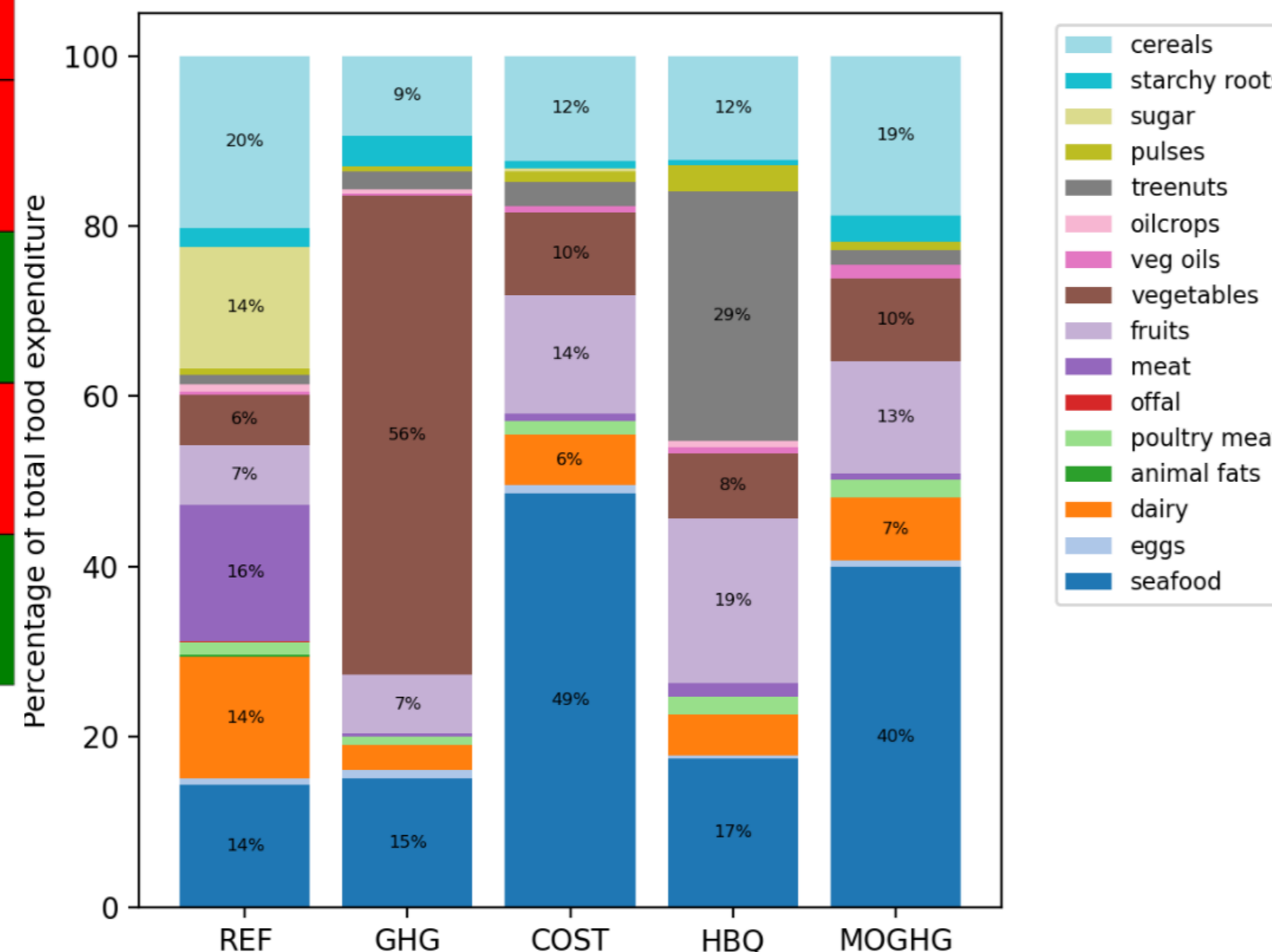
Note: GHG: greenhouse gasses emissions; WU: water use; Eutr: eutrophication; BD: biodiversity loss.

### 4. Economic dimension

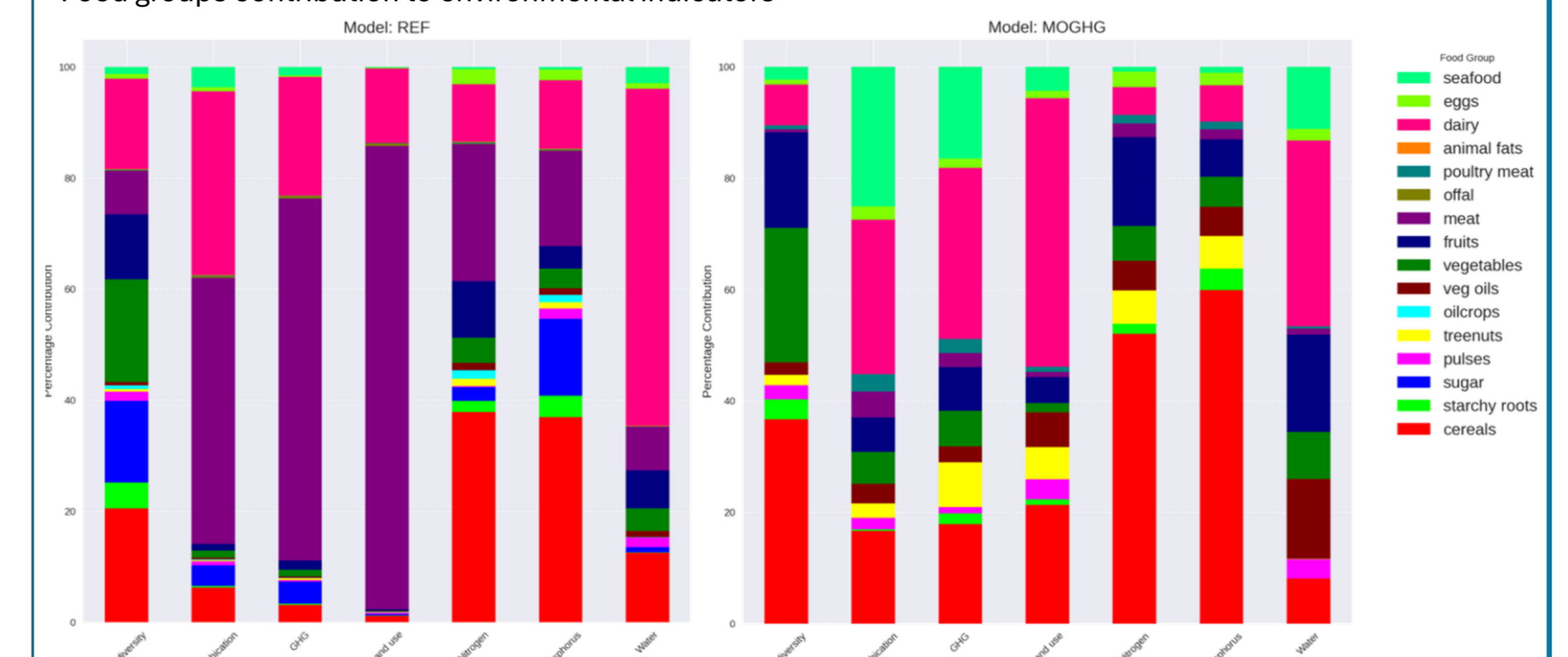
Affordability per optimization model (by income quintiles)



Percentage of cost contribution of each food group by dietary model



Food groups contribution to environmental indicators



## Conclusion

- The methodological approach such as using national versus international food consumption data, considering food waste and edible portions, and different affordability thresholds, yielded important differences in the results.
- This study demonstrates the **feasibility of designing sustainable diets that simultaneously address multiple dimensions** through optimization modeling.
- The methodology can be applied to different contexts to inform dietary guidelines and food policies aimed at improving nutrition and sustainability.